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ABSTRACT

Some of the issues associated with the lack of a precisely stated theory of memory organization are considered. The first section provides an overview of the concept of organization. Emphasis is on problems associated with the definition of organization, especially the distinction between organization as a process and as the product of a process. A definition of organization is offered that is linked to a problem solving view of list learning. The second section attempts to provide an overview of the different types of organizational processes and strategies that fall within the domain of a theory of organization. Of particular concern are the problems that have arisen because single and multiple measures of organizational strategies have been derived in the absence of specific process theories. The final section attempts to consider the strengths and weaknesses of a precisely specified theory of free recall, embodied in a computer program called Free Recall by an Associative Net (FRAN). (Author/GK)

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PROCESSES, PRODUCTS, AND MEASURES OF MEMORY ORGANIZATION

JAMES W. PELLEGRINO AND ALBERT INGRAM

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Table of Contents

Introduction 1

The Concept of Organization 2

Organizational Strategies in Free Recall 7

Unitization--A General Strategy 7

Situationally Determined Strategies 20

Interrelationships Among Organizational Strategies . . . 24

Theories of Organization 29

FRAN 29

Theoretical Transitions 32

Concluding Comment 34

References 36

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Introduction

Over the course of the past 20 years, the concept of organization has achieved a central status in most, if not all, theories of human learning and memory. There are numerous behavioral phenomena that have been attributed to organization, leaving little doubt as to its importance as a hypothetical and explanatory construct. Postman (1975) has noted "that the ultimate sign of the success of a theoretical idea is that it comes to be taken for granted as part of the current body of knowledge in a discipline. This is what has happened to the concept of organization in recall, although some investigators still seem to find it useful to document it anew" (p. 323).

The purpose of this chapter is not to provide yet another demonstration of the phenomenon of memory organization, but to consider some of the issues associated with the lack of a precisely stated theory of organization. This theoretical deficit has led individuals such as Murdock (1974) to conclude that "Organization theory is not so much a theory as a point of view. It is a belief, if you will, that there is more to human memory and learning than the simple associations studied under the aegis of behaviorism and interference theory" (p. 215).

Many researchers in the area of human memory would be inclined to agree that this assessment is still valid. An obvious question is why such a theory has not been forthcoming. In an attempt to answer this question, the first section of this chapter provides an overview of the concept of organization. Emphasis is on problems associated with the definition of organization, particularly the distinction between organization as process and the product of a process. A broad definition of

organization is offered that is linked to a problem solving view of list learning. The second section of this chapter attempts to provide an overview of the different types of organizational processes and strategies that fall within the domain of a theory of organization. Of special concern in this section are the problems that have arisen because single and multiple measures of organizational strategies have been derived in the absence of specific process theories. The final section of this chapter is an attempt to consider the strengths and weaknesses of the most precisely specified theory of organization, the FRAN theory of Anderson (1972). Consideration is given to the role of such a theory in the development of a general theory of memory organization.

The Concept of Organization

The lack of a coherent and well-specified theory of organization may be partly attributed to the way in which organization has been defined and then studied. Many of the operational definitions that have been proposed are extremely circumscribed and paradigm specific. Furthermore, most definitions do not include the concept of an internal process, but rather focus on the characteristics of some external product (Voss, 1972). Examples of this problem can be seen in definitions offered by Mandler (1967) and Tulving (1968). Mandler has proposed that "A set of objects or events are said to be organized when a consistent relation among the members of the set can be specified and, specifically, when membership of the objects or subsets (groups, concepts, categories, chunks) is stable and identifiable" (p. 330). Such a definition is clearly applicable to the sorting paradigm that Mandler (1967; Mandler, Pearlstone, & Koopmans, 1969) has studied so extensively. The result of this definition is Mandler's specification of the measure of organization as the number of categories or groups used in achieving a stable sort. Thus, emphasis is placed upon the product of some internal process, with particular emphasis on the number of groups produced. Less emphasis is placed on the formation and content of those groups, two related areas of investigation that might provide some insight as to the nature of the process.

Tulving (1968) has provided definitions of organization that apply to the free recall paradigm, and here too, emphasis is on characteristics of the product rather than the process giving rise to the output structure. "Organization defined in the weak sense refers to consistent discrepancies between input and output orders that are independent of the subjects' prior familiarity with a set of input items" (p. 15). Organization defined in the strong sense is "when the output order of items is governed by semantic or phonetic relations among the items or by the subjects' prior, extra-experimental or intra-experimental acquaintance with the items constituting a list" (p. 16).

Tulving's definition of organization in the strong sense, or what he termed secondary organization, was meant to cover two basic free recall phenomena, clustering and subjective organization. The emphasis upon organization as an empirical phenomenon that can be measured in the recall protocol has spawned a large amount of work on defining the "best" measures of organization. Thus, organization has often been defined in terms of some single score or value that purportedly reflects the total amount of organization that a subject has demonstrated. As noted by Colle (1972), such an approach has not been directly tied to an explicit process theory of organization.

Despite the fact that most definitions of organization have been unduly restricted, it is important to note that researchers in this area have not ignored the distinction between organization as both a process or set of processes and the product or structure resulting from those processes (e.g., Tulving, 1962; Sternberg & Tulving, 1977). Clearly, the stable groups that result in a sorting task and the clustering and subjective organization that occur in free recall protocols must result from some process(es) that acts upon the input in order to satisfy the goal of producing an internal representation that is stable, efficient, and readily retrievable. An adequate definition of organization must be capable of embracing such characteristics as well as the more restricted definitions offered in the past. Such a definition might take the following form--organization refers to the process(es) whereby the organism attempts systematically to store and retrieve the information presented

so as to maximize performance. It must be recognized that this definition obviously does not satisfy the need for a theory of organization. Such a theory would have to specify in detail what the processes are and how they operate. However, the definition does satisfy a number of other minimal requirements that serve to establish some constraints on such a theory. First, it localized organization within the organism (Voss, 1972). Second, it is not restricted to any particular pardigm or task (Bower, 1972). Third, it is not restricted to any particular form of internal representation, e.g., hierarchical versus non-hierarchical. Fourth, it implies that stable memory structures are the end product. Fifth, it implies that the internally generated memory structure will be reflected in the outcome of the output or retrieval process, albeit less than perfectly given that a variety of output processes may operate. Finally, it implies intentionality on the part of the organism due to an awareness of inherent limititations on the amount of information that can be stored and/or retrieved at any point in time (Mandler, 1967; Miller, 1956).

The definition we have provided is intended to reflect a strong bias toward viewing learning-memory paradigms as problem solving situations. It seems legitimate to conceive of list learning as problem solving because the individual is typically given a general goal, i.e., try to learn all the words, sentences, etc., that I present to you so that you can recall (recognize) them for me at some later time. Some very general rules are specified and the learner is then left to his or her own devices to attain the goal. Tulving (1964) and others have appropriately noted that in a task like free recall, individuals are not learning the items per se, since they already exist within the semantic knowledge system, but instead the individual must learn to discriminate the set of admissable items in the experimental context and to retrieve (reproduce) those items with minimal external support. In order to attain these specific goals the learner has at his/her disposal a number of strategies, all of which can help overcome inherent limitations on the storage and retrieval of information. These strategies operate during the input and output phases of the task and they are methods (means) to

satisfy the overall goal of the task as well as specific subgoals. An example of a subgoal might be trying to remember those items that were not remembered on the preceding trial. To satisfy this particular subgoal, the individual may utilize a variety of coding (input) and retrieval (output) strategies and these strategies, in turn, may consist of one or more elementary processes.

The distinction between strategy and process that we intend to use is the following: A strategy is a general tactic or method that may be applied in a variety of situations and its value is a function of the task being attempted and the existence and operation of alternative strategies. An example of a strategy that can be applied in list learning is attempting to form bizarre and interacting images to link the items in a paired associate list. The value of this strategy will be a function of the concreteness of the list materials. To execute this strategy, one must employ more elementary processes such as encoding, search, comparison, discrimination, etc. Thus, in the case of an interactive imagery strategy, one may need to utilize a variety of processes associated with the retrieval and generation of various codes within the permanent memory system.

It is reasonable to ask whether the definition of organization that we have offered and the emphasis on problem solving can contribute to an understanding of the concept of organization and the development of a theory of organization at this point, but it should be clear that such a theory must be able to capture all the various levels of cognitive activity that serve to define organization. Thus, a theory of organization is not simply a theory of the elementary processes that serve to make up a particular strategy, but it must also be a theory of the "executive" routines or higher order strategies that select among and coordinate various strategic activities. Such a theory must also specify the conditions that give rise to the use of a particular strategy.

One possible way to approach the development of a theory of organization might be to develop a theory of organization in a task such as free recall, with particular emphasis given to elucidating the various strategies and processes governing free recall performance. Of all

the list learning tasks, free recall seems to be the best candidate for the development of an organization theory that could have potential generalizability. Such an assumption is based on the fact that it is the least structured of all the list learning tasks and, therefore, allows for more flexibility on the part of the individual learner (problem solver). This flexibility in solution seems to generate a variety of phenomena that demand a broad concept of organization. This emphasis on free recall is not intended to ignore the study of organization in other tasks. Bower (1970, 1972) has provided excellent illustrations of apparent organizational phenomena in paired associate and serial recall tasks. The examples he provides of the use of mediation strategies in paired associate learning, and grouping in serial recall (see also Martin & Noreen, 1974) certainly fall within the scope of the definition of organization offered earlier. It is the case, however, that the free recall paradigm has served as the major vehicle for studying organizational factors in memory and it is within the large literature on performance in this task that many issues have been raised, some of which are in need of re-evaluation.

The next section of this paper is a review and discussion of several organizational strategies that seem to govern free recall performance. The presentation and discussion of these strategies serves two purposes. First, it permits a discussion of the availability of well-defined process explanations for each of the various organizational strategies that are elements of a theory of organization. The general lack of such process formulations had led to some serious problems in the area of measurement and this will be discussed in detail. Second, any theory of organization in free recall must incorporate all of the various strategies that seem relevant to performance. This involves not only inclusion of the strategies within the theory, but also the conditions surrounding the selection of a particular strategy. Thus, one of the issues to be considered is the interaction of various organizational strategies and the implications for theory and measurement of free recall organization. In the final section of this paper we will consider how well Anderson's detailed theory of free recall learning (FRAN)

handles these issues and whether a theory of free recall is simply a specific instance of a more general theory of memory organization.

Organizational Strategies in Free Recall

Unitization--A General Strategy

One of the predominant strategies in virtually all list learning and memory tasks is the unitization or chunking of individual items into larger units of information. For the purposes of the present discussion we will not attempt to separate out those aspects of unitization that may operate during the input or encoding-storage phase of list learning versus the output or retrieval phase of such tasks. In the past there has been controversy about whether organization was a storage and/or retrieval phenomenon (e.g., Allen, 1969; Slamecka, 1968, 1969). It would appear that there is a sufficiently large data base to indicate that retrieval cannot be independent of what occurs at input or storage (e.g., Pellegrino & Salzberg, 1975; Watkins & Tulving, 1975). Furthermore, studies of rehearsal patterns during input provide support for the correspondence between functional input order (e.g., Rundus, 1971) and actual output order or grouping.

Unitization as a strategy may involve several basic or elementary processes such as search, comparison, rehearsal, etc. A process theory capable of specifying all the elementary processing activities that operate in the context of a unitization strategy has not been specified, although fragments of such a process model can be found. The majority of research associated with studying unitization has focused on the two predominant manifestations of this strategy, namely clustering and subjective organization. These two phenomena provide unequivocal support for the existence of this strategy and the remainder of this discussion will focus on issues associated with the theory and measurement of these specific examples of the more general strategy.

Clustering. The empirical phenomenon of clustering is most often mentioned in any argument for the existence of a strategy whereby

individual items are grouped together into higher order units which serve as the functional basis for recall. The demonstration of clustering is based on the presentation and test of a list with certain predetermined relationships among the items. The relationships can be of a conceptual, associative, or acoustic nature (among others) with subsets of the items forming separate groups and each of the items within a particular subset sharing a certain characteristic. Clustering is said to have occurred if the ordering of items in the recall protocol reflects the experimenter-defined structure of the list. The nonrandomness of the recall protocol as contrasted with the typical random order of presentation presumably reflects the discovery and utilization of the structure implicit in the list. The earliest demonstrations of clustering were provided by Jenkins and Russell (1952), and Bousfield (1953).

The empirical phenomenon of recalling together items sharing a particular characteristic such as common category membership is only one basis for assuming that higher order units have been created. Certainly, if such units exist then the members of those units should be produced in close spatial and temporal proximity. Considerable effort has gone into quantifying the degree of spatial proximity of conceptually related items in written recall with much less effort expended in studying the temporal characteristics of oral recall. However, the study of oral recall has provided strong evidence that retrieval is based upon higher order units. One example is a study by Gelfand (1971) on the oral recall of conceptually structured lists. The data of interest were interresponse times in the production of individual list members. When members of a particular category were recalled in sequence short interresponse latencies were followed by long interresponse latencies reflecting the point at which a transition between categories occurred. Such results are consistent with the assumption of at least two phases in the retrieval process: (a) accessing a particular memory unit, and (b) reading out the members of that unit. In cases where the memory units of interest cannot be specified pre-experimentally, patterns of interresponse times have been suggested as a means of identifying these units (e.g., Chase & Simon, 1973; Reitman, 1976).

In addition to the temporal and spatial properties of recall protocols, there exist a variety of other data which support the concept of unitization. If the higher order unit serves as the basis for recall, then recall of the individual members of these units should be an all-or-none process. One way to demonstrate such an effect is to partition total recall into the number of categories represented in the recall protocol and the average number of instances recalled per category. These two measures, category recall (CR) and items per category (IPC), multiplicatively define total recall. If items are organized into units, then partitioning recall over successive trials or experimental conditions might be expected to indicate constancy in the value of IPC and changes in CR. Such a result was shown by Cohen (1966) for the recall of conceptually structured lists. A more powerful demonstration of the same phenomenon has been provided in cuing studies. As an example, Tulving and Pearlstone (1966) compared the free and cued recall of conceptually structured lists varying in the number of categories and total list length. The difference between free and cued recall was primarily restricted to lists containing six or more categories. The benefits derived from presentation of category cues were attributable to increases in CR rather than changes in IPC. Thus, Tulving and Pearlstone (1966) argued that more information was available than accessible and the loss of information was due to the failure to retrieve category units that were recallable in an all-or-none fashion. Studies by Tulving and Psotka (1971) and Strand (1971) on retroactive interference in categorized lists have illustrated that there can be selective loss and reinstatement of the retrieval cues that provide access to the memory units and their contents.

There is little doubt about the existence of a unitization strategy in the acquisition and retention of conceptually structured lists. Debate does exist in the area of how to quantify or measure the extent to which such a strategy has been employed by an individual with respect to particular experimenter-defined units. The debate is a curious one since all participants agree on one of the basic components entering into the final measure, namely the number of intraunit repetitions in

the recall protocol. An intraunit repetition is the immediate sequential co-occurrence of two items from the same experimenter-defined unit. The observed number of repetitions can be related to a number of other statistical properties of the protocol being considered. These include the number of repetitions that could be expected by chance as well as the maximum and minimum number of possible repetitions. All of these statistical properties have been combined with the observed number of repetitions to derive some quantitative organizational score variously labelled RR, SCR, ARC, etc., and Murphy provides a detailed treatment of these indices. The proliferation of measures has led to several reviews and comparisons of these measures (e.g., Colle, 1972; Shuell, 1969, 1975); but with no apparent resolution of the issue as to which is the best measure. Most recently, Shuell (1975) has raised the question of "best for what?" since the various measures differ in certain key assumptions.

Colle (1972) has pointed out that the measurement problem is not simply an empirical question, but that the development and testing of measures must be intimately related to theoretical concerns. The current problems with respect to measuring the amount of unitization (clustering) stem from the lack of a precise theory of the process underlying the clustering phenomenon. "One of the first problems which had to be solved was to demonstrate that category clustering did exist. Two approaches are possible. A theory describing the mechanism responsible for clustering could be constructed, and the measure of clustering derived from this theory (i.e., the clustering parameter) could be shown to be greater than zero. The simpler approach, which was taken, is to construct a theory which describes a recall mechanism that does not produce clustering, and to reject this theory . . . The large number of repetitions (or the small number of runs) observed in the recall of categorized lists usually allows this theory to be rejected. Hence, the existence of a clustering effect can be established" (Colle, 1972, p. 624). Given that clustering does exist we are still left with what Colle (1972) refers to as the scaling problem. Different assumptions have been made in attempting to

develop measures which yield clustering values along a measurement scale. The debate that has ensued concerns which of these scaling solutions is most appropriate. There is no resolution of this debate because no tests have been provided of the theoretical adequacy of the assumptions involved in the various scaling methods.

Perhaps it is time to reconsider the motivation behind attempting to derive measures of clustering. Ultimately, such measures should contribute to answering empirical and theoretical questions. One such theoretical question is the relationship between level of recall and level of organization. Answers to these questions have been sought by using the various clustering indices that have been developed, and there is no agreement among the answers obtained. The lack of agreement may be attributable to differences in the theoretical assumptions and adequacy of the measurement procedures, as well as to statistical properties of the derived indices that render them inappropriate for answering certain questions. Thus, we agree with Colle (1972) when he asserts that "measures of clustering cannot be constructed without a theory which describes the mechanism producing clustering" (p. 631). The chapter by Murphy provides a basis for addressing some of the issues associated with the statistical adequacy of various measures. The detailed information that he provides about confoundings between measures that will allow tests of particular hypotheses about recall-organization relationships. There is an implicit theory in his simulation work and this theory provides the basis for selecting an "unbiased" measure. Some might argue with such a theory, but efforts of this type are a first step toward specifying process models and sets of theoretical assumptions dealing with the storage and retrieval of list members.

Acceptance of the fact that there are problems in measuring clustering adequately does not imply that the phenomenon itself should be dismissed. We can reject the hypothesis that recall of conceptually structured lists is a random process. The non-randomness of the recall order reflects interitem dependencies that typically correspond to the conceptual, associative, or acoustic structure that has been

built into the list. Such interitem dependencies in recall order suggest a unitization strategy which is further supported by the selective loss and reinstatement of entire subsets of items from a list.

Subjective organization. The operation of a unitization strategy has also been assumed for the learning of lists that do not have any immediately apparent structure, i.e., lists of "unrelated" items. This assumption is based upon the fact that the recall order of the items comprising such a list is also non-random and shows increasing stereotypy over successive trials. The initial demonstration of this "subjective organization" phenomenon in unrelated lists was provided by Tulving (1962).

Sternberg and Tulving (1977) point out the different ways in which the term may be used. "Subjective organization, like many other terms in psychology, refers to two different, albeit closely related, concepts. One is a psychological process; the other is a measure of the extent to which the process is revealed in observable behavior . . . When the subject studies the list, he groups (organizes) more and more individual list items into higher order S units; when he recalls the list, he retrieves S units one at a time and produces the constituent words of each in succession . . . To measure subjective organization usually means to measure the extent to which the output order of words is sequentially constrained over successive trials . . . The degree of output consistency over trials can thus be used as an index of the extent to which a particular organization has occurred and is maintained from one trial to the next" (p. 540).

A major issue in the study of subjective organization has concerned its measurement, and the problems have been somewhat more complex than in the case of clustering. When a conceptually structured list is the object of study then it is possible to specify beforehand what higher order units are of interest. The utilization of those units can be measured in terms of simple sequential repetitions of any items from within that unit. The constraints on specific item ordering within that unit are of no concern. For example, it is of no consequence if an

individual recalls duck, chicken, goose, turkey versus duck, goose, chicken, turkey. In both cases the number of category repetitions is three and the variability of order within the category unit does not affect the measurement procedure and final score. However, when there is no prior basis for specifying what the units might be then certain measurement procedures may be insensitive to detecting the existence of higher order units in the recall protocol.

The initial attempts at measuring subjective organization in unrelated lists were based upon the number of intertrial repetitions occurring between successive groups of trials (Bousfield & Bousfield, 1966; Bousfield, Puff, & Cowan, 1964; Tulving, 1962). The number of intertrial repetitions is assessed by examining successive sequential pairs of recalled items in a given trial and determining how many of these sequential adjacencies are reproduced on a subsequent trial. The early application of this technique and the derived measures, either SO (Tulving, 1962) or ITR (Bousfield & Bousfield, 1966), was limited to a unidirectional analysis of sequential constancies. Thus, if items were sequentially recalled on one trial, but recalled in reverse sequential order on a subsequent trial then the bidirectional repetition was not recorded. Subsequent work removed this particular restriction (e.g., Gorfein, Blair, & Rowland, 1968; Shuell, 1969).

Although most research has concentrated on deriving indices of spatial proximity, there have been efforts to ascertain whether the temporal properties of recall correspond with a strategy of unitization. An example of such research is a study by Puff (1972) that demonstrated a temporal organization phenomenon similar to that described earlier for categorized lists. When successive items were members of a pairwise unit then interresponse times were lower than when successive items came from separate units. Thus, the consistent spatial orderings observed in successive recalls can be related to functional units in the temporal production of a particular output sequence.

Although the spatial and temporal measurement techniques are obviously limited, they are sufficiently sensitive to allow rejection of

the hypothesis that recall order is governed by random selection. Thus, as in the case of clustering, the initial problem of demonstrating that subjective organization exists was solved by being able to demonstrate that the value for intertrial repetitions was significantly above chance. Solution of this problem left yet another one, however. The Bousfield and Bousfield (1966) and Tulving (1962) procedures for measuring and subjective organization and the subsequent modifications to handle bidirectionality were criticized for their inability to adequately reflect higher order units of organization, i.e., units larger than size two (Mandler, 1967; Postman, 1970, 1972). "For example, it is possible that a unit of four words will be recalled together of every trial, but if the words are recalled in a different order on successive trials, both measures will underestimate the organization present" (Shuell, 1969, p. 361). This particular problem can be readily illustrated by applying the subjective organization techniques to categorized lists. When this was done by Puff (1970) the value for subjective organization was very low and was not different from that obtained for an unrelated list of items. However, the value obtained for clustering was very high. Subjects were apparently recalling the items within categories in adjacent positions, but the recall orderings within categories were varying from trial to trial thereby leading to low values of pairwise intertrial repetitions. Thus, despite the fact that pairwise intertrial repetitions allow rejection of a hypothesis of random recall, they may not provide a sufficient basis for measuring the degree of organization or unitization that has occurred.

Mandler, Worden, and Graesser (1974) have offered other arguments for the inadequacy of a pairwise measurement approach. They attempted to disrupt learning by selectively removing list items and replacing them with new items for the next learning trial. In their first experiment, the selection procedure attempted to disrupt performance by eliminating the basis for pairwise organization as represented in the output order. Thus, every other item in the recall protocol was eliminated from the list and this selective replacement condition was contrasted with non-selective replacement. All the

replacement conditions disrupted learning, but there was no difference among them. Mandler et al. (1974) concluded that "The experiment did not provide evidence about acquisition in the absence of organization. Rather, it demonstrates the difficulty of disrupting subjective organization in any simple fashion. In particular, the results cast serious doubt on the assumption that the primary organizational structure of lists of unrelated items involves relations in pairs of items" (p. 224). A second experiment provided support for the assumption of higher order units with nodal elements. The elimination of these elements lead to a serious disruption of acquisition performance.

In an attempt to resolve some of these potential measurement problems, Pellegrino (1971) developed procedures which permit the assessment of intertrial repetitions of any size unit under a variety of different sequential ordering constraints. Pellegrino and Battig (1974) pointed out that empirical justification for criticisms of the pairwise measurement techniques required demonstrating that higher order units were, in fact, formed and that such units had internal sequential organization, employing the measurement techniques developed by Pellegrino (1971), provided the necessary evidence for the existence of units larger than size two with internal sequential variability (Pellegrino & Battig, 1974). Of particular interest was the fact that the internal sequential variability of such units was greatest during the second half of learning and that typical random presentation of unrelated lists did not foster the development of such units until relatively late in learning.

Given that it is possible to demonstrate empirically that such higher order units exist the question remains as to whether the measurement of such units makes a substantial difference in accounting for performance differences at the group or individual subject level. The values obtained for organization based upon higher order units were shown to be more consistent with recall differences among conditions, and multiple correlation analyses supported this conclusion at the group level. However, the assessment of higher order units did not significantly enhance the correlation between organization and recall

for individual subjects in the typical unrelated random list condition. Thus, the utility of measuring higher order units is open to question. Resolution of this issue depends on whether the goal of applying the assessment techniques is to derive some quantitative value for the amount of subjective organization, or to specify the structure of the higher order units that have been formed.

If the major concern is to measure the amount of subjective organization then the same scaling issues apply as in the case of measuring clustering. Values for observed numbers of intertrial reptitions of unit sizes two, three, four, etc., can be obtained, along with other statistics such as the chance expected values and maximum possible values (Pellegrino, 1971). These statistics can be combined in various ways to yield different scaling solutions for deriving a score for each unit size. Which scaling solution is most appropriate depends upon the assumptions and theoretical adequacy of each, just as in the case of clustering. Recently, Sternberg and Tulving (1977) have attempted to answer the question as to which scaling solution is best and whether one needs to measure intertrial repetitions for units larger than size two. Their comparison among measurement procedures was not based upon the theoretical adequacy of the scaling solutions since current theory does not permit such an assessment. Instead, they employed psychometric criteria to evaluate the various measures. They justifiably point out that arguments for or against a particular measure have been based upon intuitive criteria that have not been either theoretically or psychometrically verified. The psychometric criteria that they specified were: (a) quantification, (b) reliability, (c) construct validity, and (d) empirical validity. The first two criteria are straightforward, but the latter two require some clarification. In the case of construct validity they state: "This criterion requires that there be some theory which relates the measure of subjective organization to the hypothesized organizing process . . . The theory we propose to adopt is that described above as the theoretical basis for output adjacency measures (Tulving, 1962). This theory relates subjective organization as a psychological construct to subjective

organization as a measured entity, and thus serves as a basis for the construct validation of the various measures" (p. 547). The criterion of empirical validity "requires that there be a theory which relates measures of subjective organization to some other measurement. We adopt the theory that increasing subjective organization underlies the improvement that occurs on successive trials of multitrial free recall" (p. 547).

These criteria were applied to data derived from a multilist-multitrial free recall study employing unrelated randomly presented lists. Sternberg and Tulving (1977) report a variety of data concerned with the reliability and empirical validity criteria and conclude that the best measure of subjective organization is the modification of the orginial Bousfield and Bousfield (1966) intertrial repetition measure which expresses the deviation between the observed and chance expected number of bidirectional pairwise repetitions. This conclusion may be appropriate given the limited set of conditions in which organization was assessed, and it is consistent with data reported by Pellegrino and Battig (1974) for similar conditions. As noted earlier, higher order units may not be formed until relatively late in learning, particularly in unrelated, randomly presented lists. Thus, the failure to find evidence supporting the existence, reliability, and utility of such units is not surprising. This does not, however, rule out their presence and value in understanding differences between a variety of list structure and presentation conditions that are known to affect recall. At best, Sternberg and Tulving's conclusion is of limited generality.

Issues of generalizability aside, it remains necessary to question the utility of this whole measurement and testing exercise. The separation of theory and measurement that Colle (1972) discussed in the case of clustering is still true for the case of subjective organization. There is no evidence to support the theoretical adequacy of the measure designated as best since the theory giving rise to the test of construct validity is very general and does not specify the size or structure of the unit to be measured. The criterion of empirical

validity that was employed limits the value of the whole measurement operation. Conceivably, the measure should permit the investigation of theoretical issues, one of which is the relationship between organization and recall. However, the measure that has been designated as best has the property of maximizing that relationship given that the correlation between organization and recall was one of the criteria for selection. Perhaps, the measure could be used as an individual difference variable as Sternberg and Tulving suggest, but the long range gain of doing so has yet to be demonstrated. Even if a subjective organization score could be shown to be a reliable predictor of something meaningful, something other than level of recall, there would still be an interpretive problem arising from the loose theoretical underpinnings of the measure itself. Again, we are led to conclude that measurement apart from theory may be a somewhat empty exercise.

Organizational structure. Lately, research emphasis has shifted towards identifying the structure of organization, i.e., the higher order units that are formed, their constituent elements, and the relationships among these units and elements. Part of this shift in emphasis can be attributed to a recognition of the methodological and theoretical inadequacies of attempting to measure the amount of organization. Another contributing factor has been the emergence of theories concerned with the representation of knowledge in memory (e.g., Anderson & Bower, 1973; Kintsch, 1972, 1974; Norman & Rumelhart, 1975; Rumelhart, Lindsay, & Norman, 1972).

Various methods have been employed to assess organizational structure and some involve departures from typical free recall procedures. Examples of these include Mandler's (1967) sorting task, Seibel's (1965) study sheet paradigm, and Buschke's (1977) two-dimensional recall task. Other methods are more concerned with data reduction techniques for typical multitrial free recall protocols. Included among these are Friendly's (1977) proximity analysis techniques, Monk's (1973, 1976) hierarchical grouping analysis techniques, and hierarchical analysis techniques based upon multiple cued recalls (Reuter, 1976). Many of the more recently proposed methods

are extensions of the basic techniques developed by Pellegrino (1971, 1972) for assessing different types of higher order subjective organization units over successive recalls (e.g., Buschke, 1976; Monk, 1976; Reuter, 1976; Tangen, Ziegelbaum, & Buschke, 1976). A detailed treatment of these techniques can be found in Friendly's chapter in this volume.

There has been little systematic application of these techniques for assessing organizational structure, and it is to be expected that debate will ensue as to which technique is most appropriate. Evidence that this is happening can be found in Monk's (1976) and Reuter's (1976) criticism of the proximity analysis procedures developed by Friendly (1977). We hope that the course of this debate will be tied to theoretical issues. Attempts to study the structure of organization, including the content, size, and development of higher order units, may lead to the development of more precise and testable models of unitization with subsequent advancement in the quanitification of organization, if the latter is deemed a desirable goal (see Buschke, 1976).

It is now 25 years since Bousfield's (1953) demonstration of clustering and 16 years since Tulving's (1962) demonstration of subjective organization. During that time considerable effort has gone into studying factors that affect free recall learning and organization. Over that same period of time the study of free recall learning and organization has become a major topic in the developmental literature (e.g., Jablonski, 1974) with assiduous application of the methods and procedures arising from the adult literature. It is not terribly surprising that developmental research on free recall has generally emphasized quantitative rather than qualitative developmental changes (e.g., Brown, 1975).

Perhaps, attempts to study the structure of organization, rather than simply the amount of organization, will provide the basis for new insight concerning both quantitative and qualitative developmental changes in the formation and utilization of higher order memory units. This may be the case if the study of free recall is linked to emergent

research on the nature and development of semantic memory. Evidence for such a shift in emphasis can be found in Ornstein and Corsale's chapter on organizational features in children's memory.

Situationally Determined Strategies

Seriation. In typical free recall emphasis is on the development of stable recall structures in the absence of any implicit or explicit structure at input. However, structure may be provided at input by presenting the items in a constant order and it is well documented that when such constancy occurs there is superior recall performance (e.g., Jung & Skeebo, 1967; Mandler, 1969a, 1969b; Postman, Burns, & Hasher, 1970; Wallace, 1970). This superiority in recall performance apparently results from the strong tendency of individuals to use the list order as the basis for ordering or organizing recall. Varying degrees of consistency in the order of item presentation lead to systematic increases in recall performance which are related to the degree of input-output organization (e.g., Chapman, Pellegrino, & Battig, 1974). Mandler (1969a, 1969b) has referred to this basis of organization as seriation and has demonstrated that it may be used almost as frequently as category clustering. The pervasiveness of seriation as an organizational strategy under conditions where there is no constraint on the order of recall has led Mandler to argue that it is an important and sometimes preferred mode of organization in human thought.

Postman (1972) has made some interesting observations on the relationship between seriation and semantic clustering as alternative strategies governing recall. He pointed out that these two bases of organization are often incompatible, but both may give rise to superior performance. The tendency to focus or measuring only one type of organization, e.g., category clustering, obviously fails to represent the diversity of organizational modes that are possible. There is also a strong possibility that assessment of only one mode of organization could lead to some misleading conclusions about group and individual differences. Research on individual differences reported

by Hunt, Frost, and Lunneborg (1973) shows how such a pot[illegible], could arise. One of the studies reported by Hunt et al. (1973) was a comparison between high and low verbal college students in single trial free recall of categorized lists. There were two conditions of presentation with the members of common categories either contiguously blocked or randomly distributed. In the case of the random presentation list, the high and low verbal subjects differed in terms of the amount of category clustering with the high verbals showing less semantic clustering at output, but higher recall than the low verbals. However, Hunt et al. (1973) reported that the high verbal subjects had a greater tendency to organize recall on the basis of the serial order of item presentation. If emphasis had only been on semantic clustering then one might have been led to conclude that semantic organization is negatively related to verbal ability. The assessment of seriation led to the somewhat different conclusion that high verbal individuals may be better able to maintain the sequential order of input.

This brief discussion of seriation was intended to emphasize two points. First, adopting the serial order of item presentation as a basis for storage and retrieval may be an extremely efficient strategy when the conditions of list presentation allow for its use. This may be the case even when alternative bases of organization exist. Second, focusing on only one particular mode of recall organization to the exclusion of others may be extremely misleading. We will return to this latter point shortly after considering two further organizational strategies in free recall.

Recency. Like the term subjective organization, the term recency can be used to refer to two related phenomena. In its most typical usage recency refers to the enhanced recall of the items occurring at the end of a free recall list. The term may also be used to refer to the strategy of recalling the terminal list items first. This strategy is what apparently underlies the superior recall performance on the terminal list items (e.g., Postman & Phillips, 1965). Recency may be viewed as an organization strategy designed

to maximize performance on a portion of the list, specifically, that portion of the list that is presumed to reside in the short term store (e.g., Glanzer, 1972) and that is subject to loss from output interference occurring during the act of recall (Waugh & Norman, 1965).

Recency has generally been treated as an automatic retrieval strategy in recall from successive single t ial lists. However, recency seems to be a learned strategy which develops as a result of experience with multiple prior free recall lists (Maskarinec & Brown, 1974). Recency is also not an automatic retrieval strategy in the recall of multitrial free recall lists. Pellegrino and Battig (1974) showed that this strategy tends to appear on the second trial and its maintenance depends upon the type of list that is being learned.

Recency is a relatively low level organization strategy--what Tulving (1968) has termed organization in the weak sense. Its importance for the present discussion of organization is that it represents yet another strategy that influences the amount, order, and structure of recall and can thus influence the values obtained for other organizational indices.

Priority. There is one more organizational strategy that merits discussion because it also influences the order and structure of recall. Battig, Allen, and Jensen (1965) provided evidence that newly recalled items, i.e., those not recalled on prior trials, tend to occur early in the recall protocol, earlier than would be expected based upon random distribution. Battig et al. (1965) interpreted the priority effect as possibly indicating that subjects develop a strategy such that newly acquired items are given special attention in recall, quite possibly because they are more susceptible to forgetting. Questions arose concerning the possible artifactual nature of the priority effect (Baddeley, 1968; Postman & Keppel, 1968; Shuell & Keppel, 1968). The major contention was that previously incorrect items are more likely to occur in initial and terminal list positions during presentation thus favoring their early recall due to the occurrence of primacy and recency effects. Also, when the recency effect was eliminated by

having an interpolated task before recall then there was no evidence for the occurrence of a priority effect. Thus, there appeared to be a complete interdependence of priority and recency effects. Subsequent research, however, has demonstrated that when conditions are created in which prior incorrect items never appear in the initial or terminal positions of the list, thus eliminating the possibility of contamination due to primacy and recency effects, there is still a very substantial priority effect that increases over trials (Battig & Slaybaugh, 1969). Further evidence demonstrating the occurrence of a priority effect has been provided by Brown and Thompson (1971) and Mandler and Griffith (1969).

The use of a new item priority strategy for recall may result from processes occurring during list presentation and study. In a study of overt rehearsal processes during multitrial free recall, Einstein, Pellegrino, Mondani, and Battig (1974) showed that newly recalled items received a disproportionately large number of rehearsals on the study presentation prior to recall. The selective study and early recall of previously non-recalled items is yet another way to maximize performance on certain items within a list. The possible interdependence between employment of the strategy and performance on new items is suggested by the fact that priority in the recall of newly learned items increases over trials as does the probability of recalling such items.

Part-whole transfer studies provide one further illustration of the use of a strategy which segregates old and new items and gives recall priority to new items. Petrich, Pellegrino, and Dhawan (1975) and Roberts (1969) have shown that under typical part-whole free recall transfer conditions there is evidence for recall priority of the new subset of items. This priority effect also increases over successive trials with the whole list. When the subject is informed about the structure of the whole list recall priority for new items is further enhanced (Petrich et al., 1975) and the level of new item recall priority is correlated with the level of recall of such items. It has been suggested by Petrich et al. that this new item priority

effect may explain why new item recall remains superior to old item recall even when the subject is informed about the list structure. The old items may suffer from output interference resulting from the adoption of this recall strategy.

Interrelationships Among Organizational Strategies

Up to this point we have considered a variety of organizational strategies that a learner has at his disposal and that are manifested during the course of free recall learning. Each of these strategies can affect the level of recall, the particular items recalled, and the order in which they are recalled. Recognition of this fact poses some serious methodological and interpretive problems. The predominant tendency in measuring organization has been to focus on only one particular type of organization, typically either clustering or subjective organization, and to assume that this reflects the total amount of organization that has occurred. Such an approach obviously ignores the possibility that alternative modes of organization are possible or important and that recall may be determined by several strategies operating simultaneously. Even if the indices of clustering and subjective organization were sufficiently well-specified and validated such that they adequately represented underlying processes, they could not adequately represent the level of organization shown by a particular subject. No single strategy index could be expected to account for the level and structure of a given recall attempt. Inconsistencies in the literature concerning the relationship between organization and recall may be attributed to this problem as well as to the more basic measurement problems discussed earlier.

Postman (1972) has pointed out that "As the evidence of multiple and divergent modes of organization accumulates, it will become increasingly important to specify their necessary and sufficient conditions and their relative weights in the performance of a given memory task. So far, the main thrust of experimental analysis has been directed toward the identification and measurement of the separate processes; the manner of their interaction now requires

explicit attention . . . The time appears to have come for a component analysis of organizational processes, and the analytic complexities are likely to be comparable" (p. 34). There have been relatively few attempts to undertake the type of analysis suggested by Postman. One such attempt was a study by Pellegrino and Battig (1974) which we will review in some detail. In this study four basic free recall conditions were investigated, representing the crossing of categorized and unrelated lists with random and constant presentation orders. Several different indices of organization were obtained and these included recency, primacy, priority, subjective organization (including units larger than size two) and seriation. Each of these different organizational strategies was manifested in recall, often in reciprocal relationship to one another, and they differed as a function of the particular type of list condition. Evidence of this interactive effect across and within list conditions can be seen by examining the different indices shown in Figures 1 and 2. These figures show changes in various measures of organization as a function of trials and particular list manipulations. Figure 1 shows performance as a function of categorical versus unrelated lists. It can be seen that the level of subjective organization (output-output) was higher for categorized than unrelated lists. However, categorized lists showed less seriation (input-output), recency and new item priority than unrelated lists. A similar reciprocal pattern occurred in the comparison between constant and random presentation conditions, as shown in Figure 2.

The extent to which a particular organizational strategy was manifested in recall also changed as a function of the level of practice as can be seen in both figures. A hierarchy of organizational strategies or series of stages was inferred such that subjects begin with a strong seriation strategy on the first trial followed by recency and priority strategies, and finally culminating in higher order subjective organization strategies. The main difference between conditions appeared to be in the second and third stages of this organizational development. In those conditions where there are semantic categories, or fixed serial orders, or both, the development of priority and recency

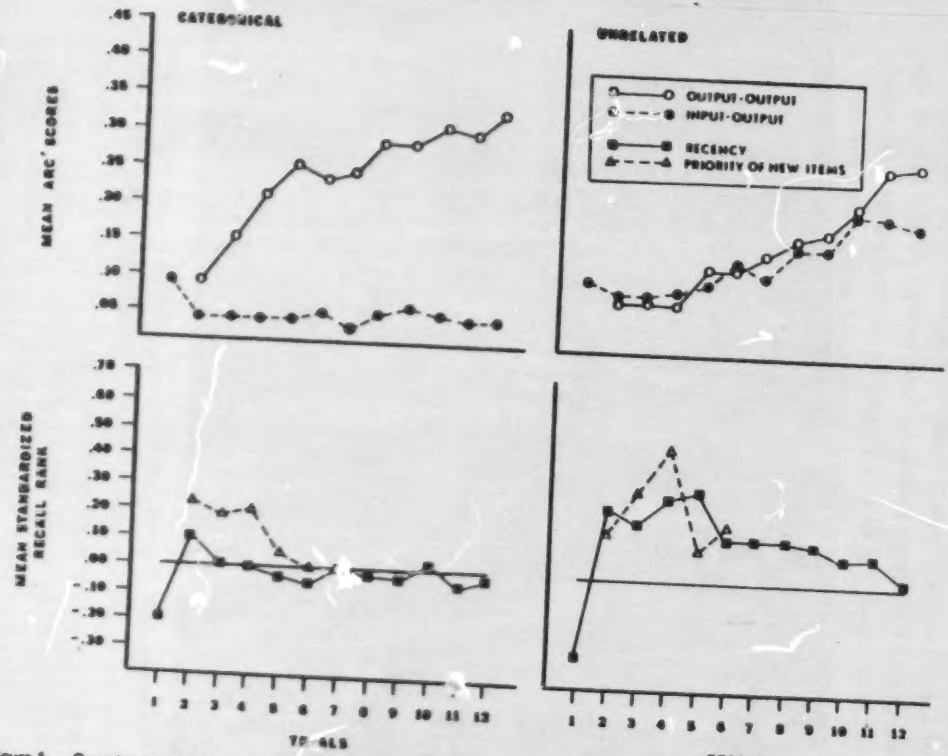

Figure 1. Organizational strategy scores in the free recall of Categorical and Unrelated lists. ARC' scores represent the ratio of the observed deviation from chance over the maximum possible deviation. Standardized recall rank scores represent average list order position in recall with positive scores indicating recall in the first half of the output sequence.

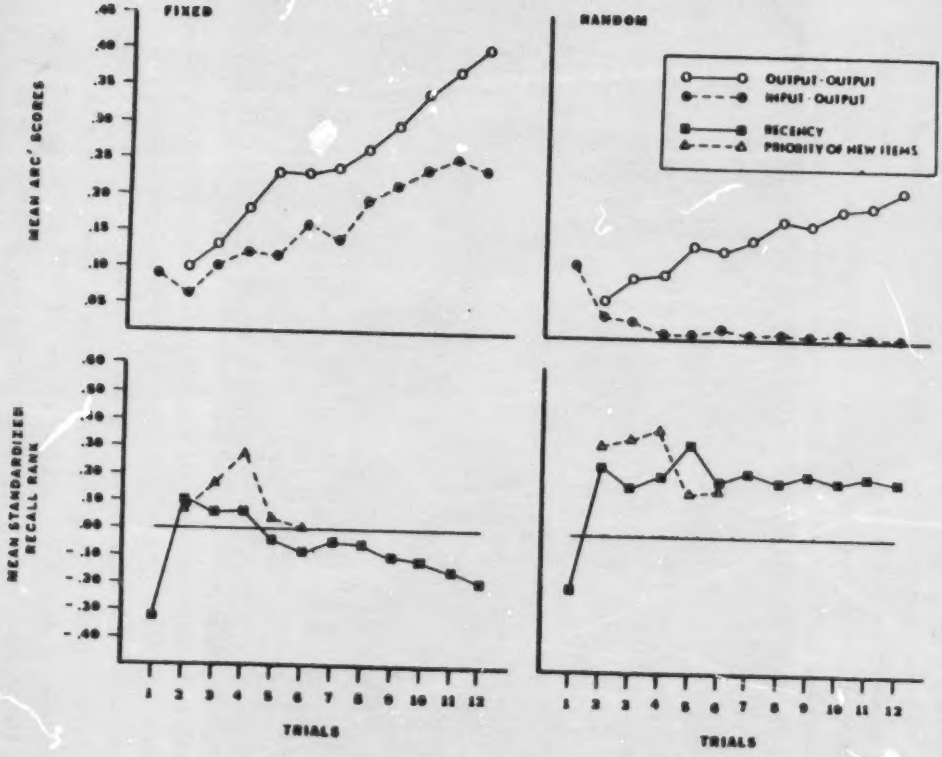

Figure 2. Organizational strategy scores in the free recall of Fixed and Random presentation conditions.

strategies is limited and individuals appear to proceed more rapidly to an organizational stage involving the formation of higher order units. Only in the typical unrelated--random conditions do individuals maintain a recency strategy and show little development of higher order subjective organization units. It appears that higher order units per se are not sufficient to explain recall differences, and that overall speed or ease of transition to this stage is equally important. Without semantic or sequential cues, individuals may be forced to operate with simpler organizational strategies.

This evidence for interactions among organizational strategies supports the contention that no single measure of organization, at least not the currently developed measures, can adequately account for the level and structure of recall. Intertrial shifts in organizational strategies need to be considered in any attempt to assess organizational structure. It is probably the case that stable organizational structures do not emerge until relatively late in learning. Thus, analytic procedures that attempt to assess the structure of organization and that are applied after learning is complete (Reuter 1976) should not be seriously affected by the multiplicity of strategies that may exist during initial acquisition.

The interaction among strategies with potential reciprocal relationships may also explain why some studies attempting to influence one form of organization have not produced changes in the level of recall (e.g., Postman, Burns, & Hasher, 1970; Puff, 1970). These studies compared conditions where subjects were given typical free recall instructions or were instructed to use consistent recall patterns across successive trials. The latter instructional manipulation increased the level of pairwise intertrial repetitions, but did not enhance the level of recall. This result may be due to a reduction in the utilization of other organizational strategies that may still operate in the standard instructional condition and thereby influence the level of recall. Unambiguous interpretation of the results of such studies is not possible since only one type of organization was assessed.

Finally, interactions among organizational strategies and changes in the utilization of these strategies over trials should be represented in any theory or model attempting to account for free recall performance. The most comprehensive model for free recall is the FRAN model developed by Anderson (1972). In the next section we will consider how it represents various organizational strategies and their interactive relationship.

Theories of Organization

FRAN

A precise theory of free recall has been embodied in a computer program dubbed FRAN for Free Recall by an Associative Net (Anderson, 1972). This program was an attempt to simulate the performance of humans in free recall tasks, and it is one of the few available efforts aimed at bringing together a variety of data into a coherent theory of processing and performance. The simulation specifically deals with the extent to which an associative theory of memory can account for extant free recall data. One of its major contributions has been to locate the problems with such a theory. We will examine the processing assumptions of the model briefly and relate them to both the preceding discussion of organizational strategies in free recall and to the wider concern of memory organization in general.

There are two major memory components in the FRAN simulation, a short-term and a long-term store. The long-term store consists of lexical items that are linked to one another by associative pathways in a net-like structure. There is at least one indirect association between any two items in this lexical network, but the primary associations for each entry were chosen on the basis of dictionary definitions and common free associations. In addition, there are one or two random associations for each entry, a feature that allows FRAN to simulate the idiosyncratic meanings that individuals often have for particular words.

When FRAN attempts to "learn" a list of words for subsequent recall, she (he?) attaches a list tag to each of the words in the list.

Tagging is a stochastic process and the probability of tagging an item varies with the length of time it spends in the short-term store. Duration in the short-term store is determined by its size, the length of the list to be learned, and the interitem associations that are processed during study. In the interval between item presentations, FRAN seeks out as many associative pathways as it can to link the current item to previously presented items. Associative pathways are tagged to guide the retrieval process. The final study operation selects items for a store called ENTRYSET. These items are the three list members that will be used to initiate the retrieval process and the choice of these items is based upon the degree of interconnectedness to other list members.

At recall, FRAN first outputs all the items still in the short-term store and then randomly selects one word from those items or ENTRYSET to begin a search through the associative net for items that have list tags. The search is a depth first procedure that follows each marked pathway to its end before going back to the nearest choice point and searching for another pathway. When all the pathways from the selected word have been examined, another word is selected to initiate the search process. To avoid repetition of the same item, FRAN marks those items that it recalls. Finally, FRAN is capable of learning at output in much the same way that it learns the list during input. Each recalled word is entered into the short-term store where it is treated as a new item and associative pathways to other list members are searched for and tagged. Thus, new retrieval pathways can be discovered during recall.

FRAN has proven to be quite competent at reproducing many aspects of human behavior in free recall situations. In particular, the simulation shows a typical learning curve, a serial position function, and most importantly, organization phenomena. The organizational strategies incorporated in FRAN that result in the simulation of free recall output phenomena include a recency strategy, as represented by the intial dumping of the contents of the short-term store, and a partial seriation strategy, as reflected by certain study biases. In

addition, there is a unitization strategy implicit in the study processes and in the use of ENTRYSET to guide recall. The items in ENTRYSET are nodal items that serve as cues for recalling chunks or units of information in a more-or-less stereotyped manner across successive recalls.

One phenomenon that FRAN does not adequately simulate is category clustering. There are some clustering tendencies exhibited in the protocols, but not at a level approximating human performance. This deficiency seems to be due to the fact that FRAN does not use non-list words in designating potential members for ENTRYSET. Thus the failure to capture clustering is not due to the failure to have represented a unitization strategy, but the particular constraints on the item selection processes as originally programmed. A modification of the processes and constraints on the strategy for ENTRYSET selection is easy to incorporate into the simulation and it would certainly improve the match between the simulation and real data for both clustering and subjective organization.

One of the properties of the FRAN theory that is most important is the fact that the theory and model provide an explicit link between the areas that Tulving (1972) designated as semantic and episodic memory. Strategies and phenomena of free recall learning are associated with episodic memory, but it is clear that they are closely related to semantic memory as well. Without knowledge of the type represented in an associative network or general semantic memory system the results of many free recall experiments would be unintelligible. Expecting an individual to recall groups of words on the basis of common category membership is unrealistic in the absence of a semantic memory system in which knowledge about such categories is stored. While we may take this for granted today, the semantic-episodic distinction is a relative newcomer and FRAN provided the first theoretical demonstration of the interaction between semantic and episodic memory functioning.

While the success of the model in simulating many basic free recall phenomena is impressive, some of its failures result from the omission of certain strategies that have been discussed previously. Included among these are seriation and new item priority. Before FRAN could simulate all the various organizational strategies and the shifts in the use of such strategies, some non-trivial changes would have to be made. "The other important direction in which FRAN should be improved is to permit her to adopt a variety of strategies and to give her some heuristic principles by which to select a particular strategy for a particular free recall task. This is much more easily said than done. Essentially, a meta-program is needed that is capable of writing a set of different programs, each program reflecting a different strategy. The program that we have developed for execution of the associative strategy would be just one of the many strategy-implementing programs . . . Although the task of programming such a meta-program is beyond our current capabilities and ideas, any fully adequate simulation program for human memory will have to take the form of such a meta-program" (Anderson, 1972, p. 373).

Theoretical Transitions

Anderson's simulation work since proposing the FRAN theory illustrates both the form that more powerful theories and meta-programs can take and the directions that memory research has taken in general. This work also serves to demonstrate how verbal learning, and free recall in particular, have raised important theoretical questions that can only be answered by examining more complex phenomena; theories at one level can and must be incorporated into higher order theoretical systems. As Anderson noted, FRAN ultimately lacked the ability to assemble even those strategies needed to simulate human performance in free recall tasks and it was not designed to be extended beyond that circumscribed domain. Human Associative Memory (HAM) (Anderson & Bower, 1973) and ACT (Anderson, 1976) were successive attempts to develop systems with wider capabilities than FRAN that at the same time retained the capabilities of the original simulation.

The theory dubbed HAM is much more ambitious than FRAN and it was designed to simulate both the structure of human knowledge and at least some of the processes that act on and use that structure. In order to achieve this greater power, it was necessary to change much of FRAN. Instead of the simple associations found in FRAN, HAM uses propositional networks that include both facts about the world and their contexts. If HAM were to learn a list of words in a free recall experiment it would replace the list tags of FRAN with a tree structure including propositions of the form "Word i occurred in the context of LIST" (1973, p. 440). Many other processing characteristics are similar in each system, and the two models would perform comparably. Most important here is the fact that HAM is capable of alleviating some of the deficiencies of FRAN not by presenting a new theory of free recall learning, but by incorporating FRAN's abilities into a larger framework. FRAN's study and recall procedures could be expanded to take advantage of the more complex memory representation found in HAM and thus produce such phenomena as category clustering and subjective organization.

Just as HAM embodies and extends important aspects of FRAN, so can ACT be seen as a system which, although it goes beyond HAM, retains and encompasses some key features of the earlier theories. A large difference between FRAN and HAM lies in the nature of the memory representation--more complete and complex semantic processing required more than the simple associate scheme found in FRAN--and the HAM model focused almost entirely on the representational issue. Although there are also differences between HAM and ACT in their representation of knowledge, the crucial change has been toward a specification of the processes that act on the knowledge base, a change brought about by the addition of a production system and its attendant procedural knowledge. Anderson (1976) has shown that ACT can also handle list learning data, although an explicit extension of FRAN is not attempted.

There are two important progressions evident in Anderson's work. One is the movement away from a simple associative framework and

the tasks associated with it to a wider view of the activities of memory. A consequence of this is the increasingly complex nature of the knowledge representations that Anderson proposes. The second progression is an increasing emphasis on the processes that act on and with memory structures. We mentioned above Anderson's evaluation of the FRAN model in this connection; the other major instance of this shift can be seen in the difference between HAM and ACT. Where HAM was an attempt to study, as far as possible, just the structure of the data base, ACT represents no such claim. By including a production system as an integral part of ACT, Anderson acknowledges the importance of studying memory and processing together; strategies and other processes are, therefore, seen as inseparable from the memory base.

Concluding Comment

In this chapter we have attempted to deal with some of the issues that arise when one attempts to cope with organization as an important memory construct. The particular issue that was emphasized was the lack of an explicit theory of organization. In our attempt to deal with this problem we provided a definition of organization and then proceeded to explore some of its implications for the domain of a theory of organization. One important aspect of such a theory is the representation of the multiplicity of strategies that are associated with organization. Attempts to measure the extent to which individual organizational strategies have been involved in list learning, particularly free recall, without providing a theory or model of the processes have led down some blind alleys. Perhaps this is to be expected given the complexity of the overall problem. Even a well-developed theory of free recall fails to capture all the complexities of a theory of organization. Organization is a systems principle that deals with both the structure and operation of human memory. A theory of organization is a theory of how knowledge is represented as well as the executive routines, strategies, and processes that create, operate on, and utilize that knowledge base.

The study of organization in list learning has profoundly influenced our conceptions of human memory and the way it is currently being

studied. Such studies have caused individuals to ask questions about a theory of organization and this had led to a realization of the larger set of theoretical issues at stake. This is a rather large intellectual debt that is often overlooked.

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